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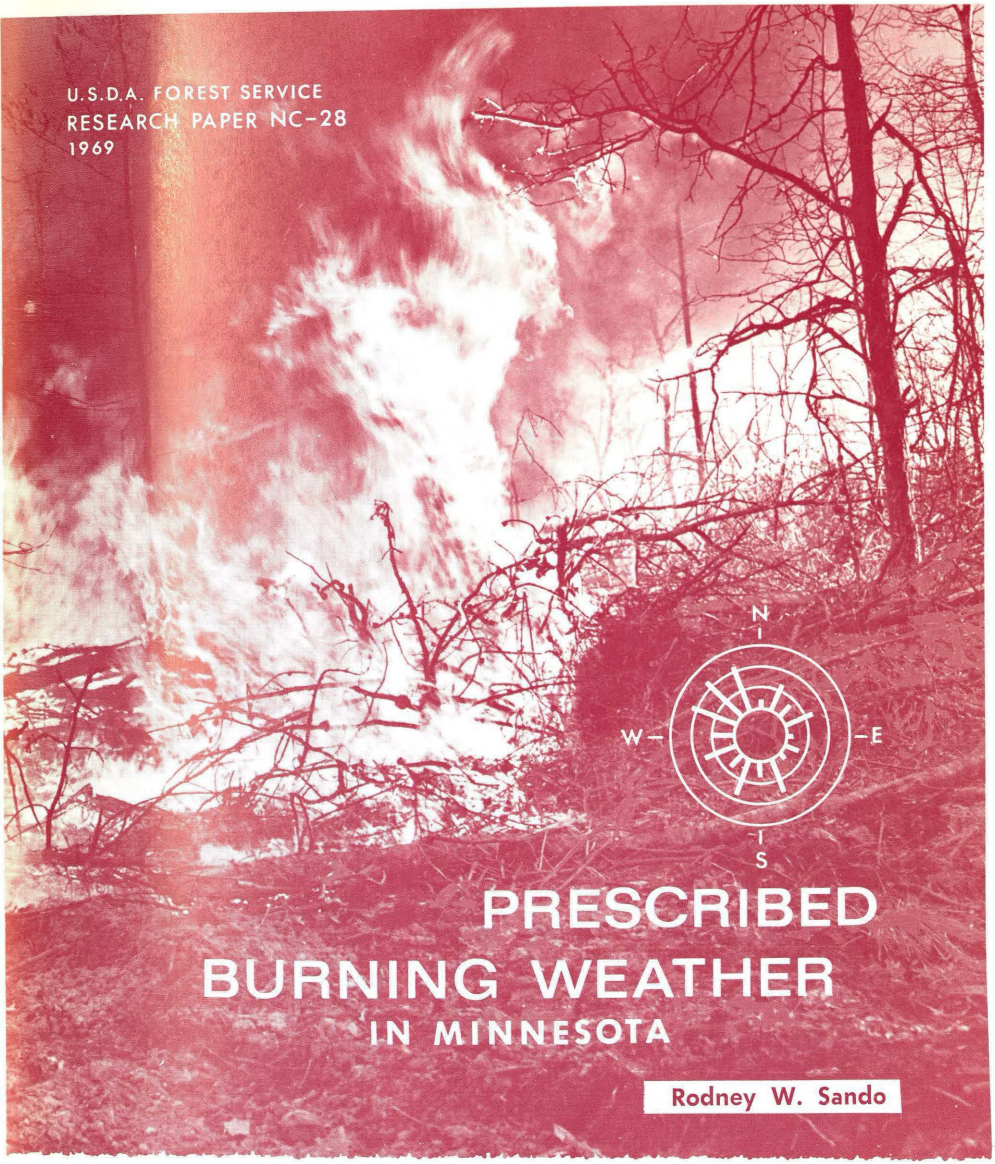

PRESCRIBED BURNING WEATHER IN MINNESOTA

Rodney W. Sando

NORTH CENTRAL FOREST EXPERIMENT STATION
U. S. DEPARTMENT of AGRICULTURE
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NOTE: The author is Associate Fire Control Scientist for the Station which is maintained in cooperation with the University of Minnesota.

North Central Forest Experiment Station
D. B. King, Director
U.S. Department of Agriculture — Forest Service
Folwell Avenue
St. Paul, Minnesota 55101

Prescribed Burning Weather in Minnesota

Rodney W. Sando

Prescribed or controlled burning is becoming a widely used forest management tool in the Lake States region. The traditional reluctance of wildland managers to use controlled burning, brought about by a history of devastating fires, is changing. As the use of prescribed burning continues to expand, definite guides for achieving each particular objective will be needed.

Successful prescribed burning calls for comprehensive planning and skillful execution. Planning a burn requires, among other things, some knowledge about the seasonal occurrence of the necessary weather conditions. Unless weather favorable to the use of fire occurs with some regularity every year, prescribed burning cannot become a truly reliable tool.

The annual precipitation pattern is probably the key factor determining the time of year prescribed burning can be done. Wind (both speed and direction) is another important weather element to be accounted for in planning prescribed burns. Wind direction in the Lake States is determined more by synoptic weather than by topographical features, so definite seasonal wind patterns do occur.

A study was made to determine patterns of weather variables influencing prescribed burning in Minnesota during the period from April to mid-November. The results of this study should be used as a guide for planning purposes only and should not be treated as a long-range weather forecast.

VARIABLES AFFECTING PRESCRIBED BURNING

The success of a prescribed burn depends greatly on the weather both before and during the burn. The most important weather variables to consider are air temperature, relative humidity, wind direction, windspeed, and precipitation. The combination of temperature and relative humidity will largely determine the moisture content of cured fine fuels. These fine fuels are important in fire spread and behavior, particularly influencing the occurrence of spot fires.

Wind direction is critical in planning a prescribed burn. Most preburn preparations such as firebreaks or fuel modifications are oriented according to a specific wind direction. Selection of the wind direction required should be determined by both the physical characteristics of the proposed burn area and the probability of the wind coming from the chosen direction on a day suitable for burning.

Windspeed is also important. Prescribed burning is generally not attempted when the windspeed exceeds 20 m.p.h., and most plans will specify a maximum allowable windspeed less than 15 m.p.h.

The number of days since significant amounts of precipitation have occurred is often used in burning prescriptions. In addition, the National Fire Danger Rating Buildup Index is used by many fire control agencies. The Buildup Index, accounts for the cumulative effects of temperature, humidity, and precipitation and can be used as an indicator of the moisture content of coarse fuels. A minimum acceptable Buildup Index is usually established for each prescribed objective. Although the magnitude of the Buildup Index has important effects on the results, plans for prescribed burning should not be written using only the Buildup Index as an indicator of the desired weather conditions; ranges for other factors such as temperature, wind speed, and relative humidity must be specified.

METHODS

Weather data for the period from April 1 to November 15 were obtained from the National Weather Records Center in Asheville, North Carolina. The data covered 10 years from 1955 through 1964 and were obtained for Minneapolis, Duluth, and International Falls. Each daily record consisted of nine hourly records for the hours from 10:00 a.m. to 6:00 p.m. and a summary record for the entire day. Wind directions were recorded for each hour using 16 points on the compass.

The National Fire Danger Rating Fine Fuel Spread Index and Timber Spread Index (Nelson 1964)[1] were computed for each of the 9 hours, and the Buildup Index (Nelson 1964) was computed for each day using the daily precipitation summary and the 1:00 p.m. wet and dry bulb temperature, and windspeed.

Seasonal herbaceous stages required for the computation of the indexes were established for each station by using a 4-year average of the dates used by the State of Minnesota's Division of Forestry station nearest each weather station for which records were obtained.

The dates used are as follows:

	Minneapolis
Spring	4/1 — 5/5
Spring transition	5/6 — 5/17
Summer	5/18 — 9/27
Fall transition	9/28 — 10/22
Fall	10/23 — 11/15
	Duluth and International Falls
Spring	4/1 — 5/12
Spring transition	5/13 — 5/27
Summer	5/28 — 9/21
Fall transition	9/22 — 10/16
Fall	10/17 — 11/15

Many days each year have weather conditions that will obviously prohibit successful prescribed burning. Only those days that met the following criteria were included in the data analysis:

1. Average relative humidity less than 70 percent over the 9 hours (Krueger and Pachence 1961).

2. No significant amounts of snow present on the ground.

3. Total precipitation less than a trace (.01 inch).

Other factors, such as excessive windspeeds or low temperatures, that would cause a day to be eliminated were accounted for in later analyses.

RESULTS

The average windspeed in Minnesota does not vary appreciably from 10:00 a.m. to 4:00 p.m. and remains nearly constant from 1:00 p.m. to 4:00 p.m. (Brown 1964). Our study shows there is little variation in the average 1:00 p.m. windspeed during the burning season (12 to 17 m.p.h.); however, April and May have the highest average windspeed and July and August have the lowest. Winds are more likely to exceed the allowable maximum in the spring; the windspeed will seldom exceed 20 m.p.h. during July and August (table 1).

Wind roses (see Appendix) for each month indicate that changes in the prevailing wind direction occur during the burning season. In addition, the conditions that make a day suitable for burning are not associated with any particular wind direction at any of the stations (fig. 1).

Radical changes in the wind direction during prescribed burning can cause serious problems. Consequently, burning should not be done under conditions that promote changes in wind direction. At the three stations, northeast winds are generally the most variable, northwest winds are the most persistent at Minneapolis and International Falls, and southeast winds are most persistent at Duluth. Also, changes in wind direction are most likely when the windspeed is low (fig. 2).

The number of days since significant rainfall has occurred will influence the effects of a prescribed burn. Periods of long duration

[1] *Names and dates in parentheses refer to Literature Cited section.*

Table 1. — Probability of the windspeed being 15 m.p.h. or less and 20 m.p.h. or less on suitable burning days (1955-64).

Windspeed (m.p.h.)	April	May	June	July	Aug.	Sept.	Oct.	Nov.
MINNEAPOLIS								
15	0.52	0.59	0.68	0.77	0.84	0.71	0.72	0.67
20	.77	.80	.91	.96	.97	.91	.91	.86
DULUTH								
15	.52	.55	.71	.77	.77	.70	.68	.67
20	.80	.79	.88	.94	.95	.90	.88	.87
INTERNATIONAL FALLS								
15	.66	.69	.82	.86	.86	.80	.75	.74
20	.86	.89	.96	.97	.97	.94	.93	.93

without rain seldom occur in this region but lesser periods occur fairly frequently (table 2).

An attempt to determine the number of days that would be suitable for prescribed burning throughout the season must utilize some predefined limits for such variables as windspeed, temperature, etc. To do this, these important factors were standardized as follows:

Criteria for an acceptable burning day

1. Fine Fuel Spread Index, 15-35
2. Windspeed, 5-15 m.p.h.
3. Relative humidity, less than 70 percent
4. No snow on the ground
5. Less than a trace of rain (.01 inch)

On this basis, 25 to 40 burning days can be expected to occur each year (table 3). Most acceptable burning days occur during summer and early fall, particularly October.

DISCUSSION

These results provide useful information on the distribution and severity of the weather conditions in Minnesota. The averages presented here should not be used as accurate weather predictors but do indicate what can occur during normal or average years.

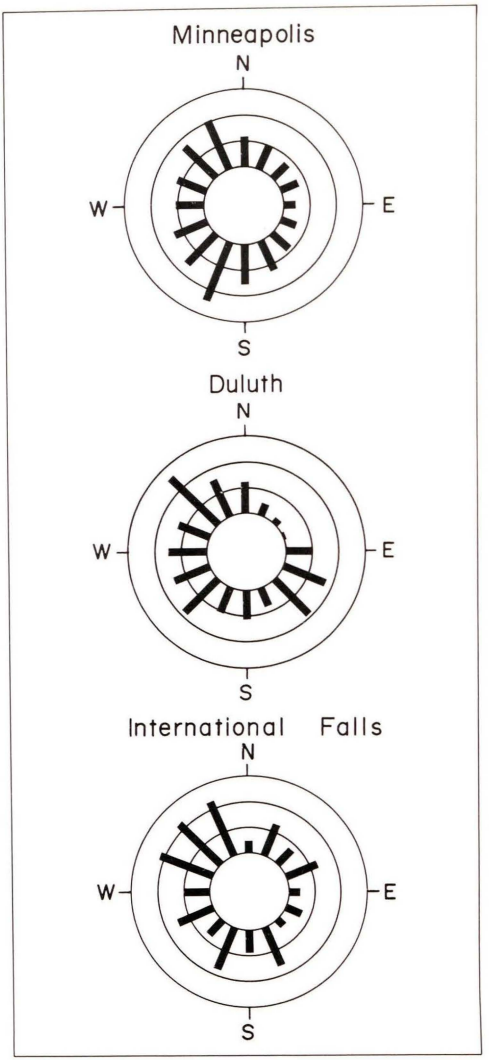

FIGURE 1. — Wind rose showing the percent of suitable days with a given wind direction. Note: each outside circle represents 5 percent.

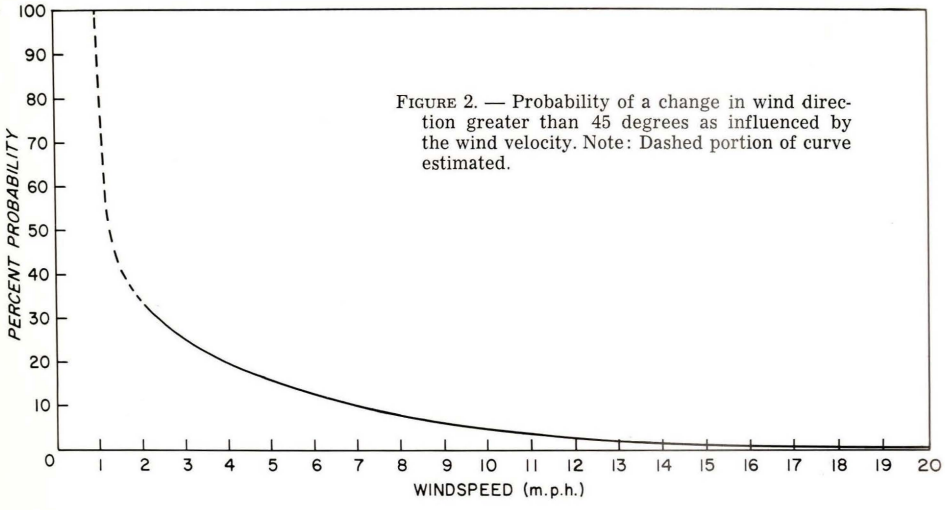

FIGURE 2. — Probability of a change in wind direction greater than 45 degrees as influenced by the wind velocity. Note: Dashed portion of curve estimated.

Rainfall distribution during the burning season is a key consideration in planning prescribed burning. The moisture content of the larger fuels is greatly influenced by precipitation and will determine to a large extent how the fire will behave and what the effects of the fire will be. Because fuel consumption depends on the moisture content of the fuel, Buildup Index may be used as the basic criterion for burning prescriptions (fig. 3). Other weather factors will largely be limited by the allowable safety and control standards.

CONCLUSIONS

Some conclusions about the weather patterns affecting a program of prescribed burning in Minnesota are:

1. Northwest winds are the most common winds on days suitable for prescribed burning.

2. The average windspeed that can be expected at 1:00 p.m. is highest during April and May and lowest during July and August.

3. Northeasterly winds are the most variable and northwesterly winds the most persistent.

4. Low-velocity winds (less than 8 m.p.h.) are much more likely to change direction than are high-velocity winds.

5. There is a 70-percent probability that the windspeed on suitable days will be less than 15 m.p.h. and a 90-percent probability it will be less than 20 m.p.h.

6. The probability of the occurrence of acceptable wind conditions is high, and unfavorable winds will generally not be the limiting factor in a successful burn.

7. From 25 to 40 acceptable burning days can be expected to occur in Minnesota each year; however, specific requirements may significantly reduce this number.

8. The months of July, August, and October are probably the best months for prescribed burning.

9. Suitable burning conditions occur most frequently in midsummer, and prescribed burning activity at this time will conflict the least with wildfire control activities.

Table 2. — Number of periods per year with X days since .1 inch of precipitation (1955-64).

Days since precipitation	Spring	Spring transition	Summer	Fall transition	Fall	Entire season
MINNEAPOLIS						
0	11	4	46	5	6	72
1	7	3	26	4	4	44
2	5	2	19	3	3	32
3	4	1	14	3	2	23
4	2	1	9	2	2	16
5	1	1	7	2	1	12
6	1	1	5	1	1	9
7	1	*	3	1	1	6
8	1	*	2	1	1	4
9	1	0	1	1	1	3
10	1	0	1	1	*	2
DULUTH						
0	16	6	44	8	10	83
1	8	4	24	4	6	45
2	6	2	16	3	4	31
3	4	1	10	2	3	21
4	3	1	7	2	2	15
5	2	*	5	1	2	10
6	2	*	3	1	1	7
7	1	*	3	1	1	5
8	1	0	2	1	1	3
9	*	0	1	1	*	2
10	*	0	1	*	*	2
INTERNATIONAL FALLS						
0	14	5	45	8	9	81
1	7	3	22	4	6	43
2	5	2	15	3	4	30
3	4	1	11	2	3	22
4	3	1	7	2	2	16
5	2	1	5	1	2	11
6	1	*	4	1	1	7
7	1	*	2	1	1	5
8	1	*	1	1	1	4
9	1	*	1	1	*	3
10	1	*	1	*	*	2

*Less than 1.

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Table 3. — Suitable burning days per year by Buildup Index classes. (In days per year)

Month	Buildup Index												
	5-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-120	121-150	Total
MINNEAPOLIS													
April	0.8	1.2	0.4	0.3	0.1	0.1	0	0	0	0	0	0	2.9
May	.6	.7	.6	.3	.2	.2	0	.1	.1	0	0	0	2.8
June	.2	.9	.3	.5	.3	.1	.1	.1	0	0	0	0	2.5
July	0	.4	1.1	.3	.3	.4	.1	.1	.1	.1	0	0	2.9
August	.2	.9	.7	.5	1.1	.4	.5	.1	.1	0	0	.1	4.6
September	.1	2.3	1.1	.4	.3	.2	.1	.1	0	0	0	0	4.6
October	0	.9	1.5	1.2	.9	.2	.6	.6	.3	.1	0	0	6.3
November	.1	1.1	.5	.3	.8	.4	.4	.3	0	0	0	0	3.9
Total	2.0	8.4	6.2	3.8	4.0	2.0	1.8	1.4	.6	.2	0	.1	30.5
DULUTH													
April	.4	1.0	0	.4	0	0	0	0	0	0	0	0	1.8
May	.1	0	.7	.5	.1	.1	0	0	0	0	0	0	1.5
June	.2	1.6	.5	.2	.1	0	.1	.2	0	0	0	0	2.9
July	.1	.8	1.1	1.1	.7	.1	.2	0	0	0	0	0	4.1
August	.1	1.3	1.3	.6	.5	0	0	.1	.2	0	0	0	4.1
September	.3	1.6	.9	.3	.2	0	0	0	0	0	0	0	3.3
October	.2	.7	1.5	1.4	1.2	.7	.5	0	0	0	0	0	6.2
November	.1	1.4	0	.2	.3	.2	.5	0	0	0	0	0	2.7
Total	1.5	8.4	6.0	4.7	3.1	1.1	1.3	.3	.2	0	0	0	26.6
INTERNATIONAL FALLS													
April	.6	1.9	.6	.1	.3	0	.2	0	0	0	0	0	3.7
May	.1	1.2	1.4	.4	.4	.2	.2	0	.1	0	0	0	4.0
June	.7	1.2	1.1	.1	.3	.2	.3	.2	.1	.1	.2	0	4.5
July	.1	2.1	1.6	.7	.6	.2	.2	0	0	0	0	.7	6.2
August	.1	1.4	1.6	1.9	.4	.4	.1	0	.1	0	0	0	6.0
September	.2	2.1	2.4	1.2	.3	.2	.1	0	0	0	0	0	6.5
October	.1	1.3	1.3	.9	.9	1.1	1.3	.6	0	0	0	0	7.5
November	0	.2	.4	.2	.1	.3	.6	.3	.3	0	0	0	2.4
Total	1.9	11.4	10.4	5.5	3.3	2.6	3.0	1.1	.6	.1	.2	.7	40.8

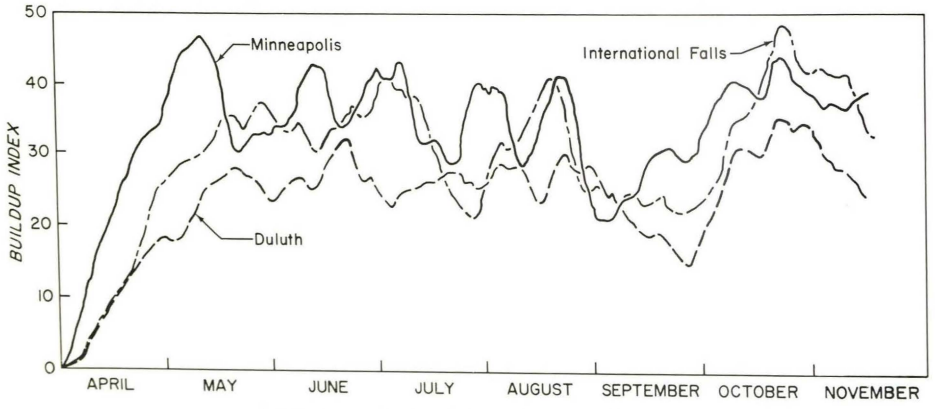
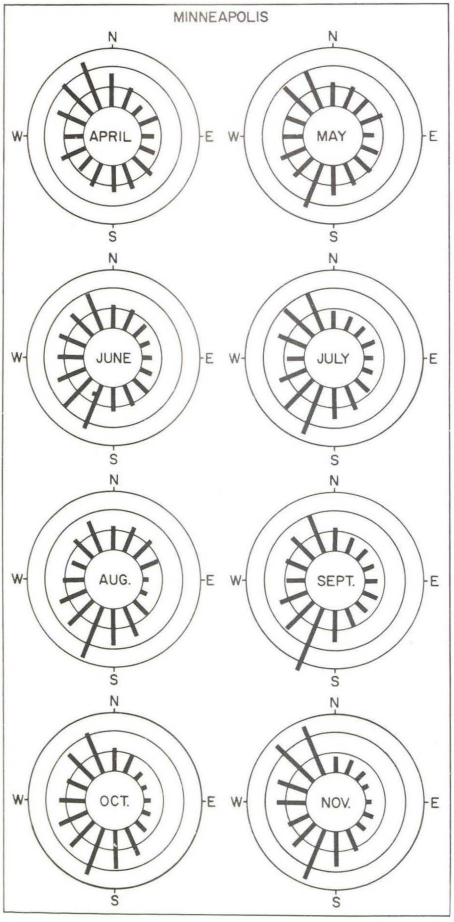
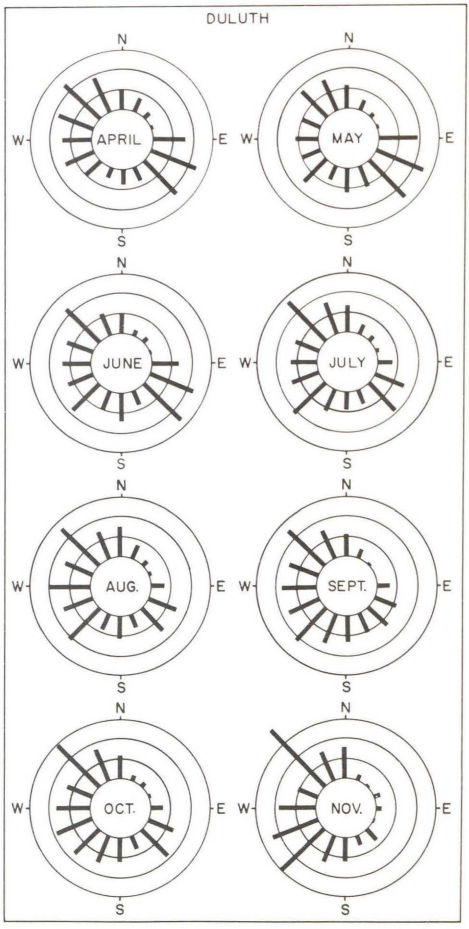


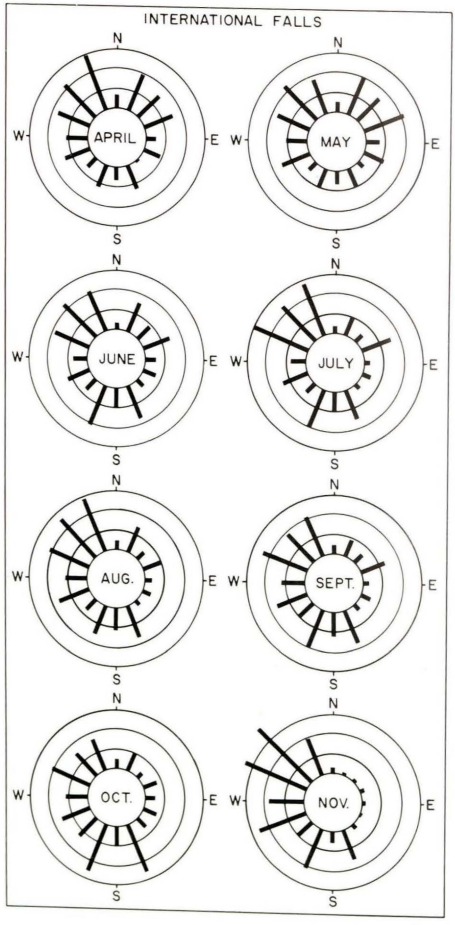
FIGURE 3. — Buildup Index trend over the season for Minneapolis, Duluth, and International Falls.

APPENDIX

Wind direction on suitable days by location and month, 1955-64
(Outside circles represent 5-percent intervals)



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